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VINELAND CHEMICAL COMPANY

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VINELAND, NEW JERSEY

Agency for Toxic Substances and Disease Registry
U.S. Public Health Service

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HEALTH ASSESSMENT

VINELAND CHEMICAL COMPANY SITE

VINELAND, NJ

PREPARED BY

OFFICE OF RISK ANALYSIS
OAK RIDGE NATIONAL LABORATORY*

FOR

THE OFFICE OF HEALTH ASSESSMENT
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

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SUMMARY

The Vineland Chemical Company Site (ViChem) is an active agrichemical manufacturing facility in the northwestern corner of Vineland City, New Jersey. ViChem is located in an industrial/residential area and has produced herbicides, pesticides, and fungicides since 1949. Improper storage and disposal operations at the plant have resulted in significant on-site contamination. Groundwater and soil are the primary contaminated media on-site; arsenic is the major contaminant. Migration of on-site contamination via groundwater movement and surface water runoff has resulted in off-site contamination of groundwater and of water and sediment in area surface water bodies. The potential is great for continued flushing and migration of on-site contamination to off-site areas. Some residents in the residential area along Mill Road near the ViChem facility may be at risk from exposure to site-related contaminants; other populations potentially at risk include recreational users of area surface water bodies. Further sampling and a well-user survey are needed in order to completely assess the health implications posed by site contamination.

BACKGROUND

A. SITE LOCATION AND DESCRIPTION

The Vineland Chemical Company Site (ViChem) is an active agrichemical manufacturing facility in the northwest corner of Vineland City, New Jersey. The 54-acre plant is situated in a mixed residential/industrial area of Cumberland County and is ranked number 41 on the National Priorities List (NPL).

ViChem has manufactured organic arsenic-based herbicides, pesticides, and fungicides at this plant since 1949. The company also produced cadmium-based herbicides and used other inorganic chemicals such as lead and mercury compounds. Improper storage and disposal of raw material and waste at the ViChem plant have resulted in significant contamination of the groundwater underlying the site and the on-site soil by arsenic, cadmium, and trichloroethene. Migration of on-site contamination has resulted in extensive off-site arsenic contamination of area surface water bodies and, to a lesser areal extent, of groundwater.

Current operations at the site include manufacturing herbicidal chemicals (disodium methanearsonate and monosodium methanearsonate). This manufacturing process produces approximately 1,170 tons of waste by-product salts each year. These salts have an Environmental

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Protection Agency (EPA) Hazardous Waste Number of K031 and the company reports that they are neither treated, disposed of, nor stored on-site for more than 90 days. ViChem employs 10-20 workers, varying with the seasonal demand for herbicides.

The plant is partially bordered on the north by the Blackwater Branch which flows westward approximately 1.5 miles before discharging into the Maurice River (Appendix A). Residential areas border the plant to the east, south, west, and partially on the north. Eight residences are in the immediate vicinity of the plant, and several other residences are located close to the plant along Wheat, Orchard, Oak, and Mill Roads. Access to the plant is along Wheat Road. The Martex Manufacturing facility is located to the north of ViChem.

The plant site includes several manufacturing and storage buildings, a laboratory, several lagoons, and former chicken coops (now used mainly for storage). The manufacturing and parking areas are paved; the lagoon area is unpaved and devoid of vegetation. The remainder of the site is covered by trees, grasses, or shrubs. The area surface and subsurface soils are predominately composed of sand.

In 1966, the New Jersey Department of Environmental Protection (NJDEP) reported that ViChem was discharging untreated waste waters into unlined lagoons, and that waste salts, reportedly containing 1-2% arsenic, were stored in former chicken coops or in open piles on the company property without adequate containment barriers. A concrete pit with cracked walls was also used for storing arsenic-contaminated waste salts. At times the salts accumulated in excess of the capacity of the pit and overflowed onto the soil surface. In information reported to EPA, ViChem personnel revealed that chemical spills in Building #9 had resulted in arsenic contamination beneath the floor of this building. Percolation of waste water from the lagoons and concrete pit, precipitation that came in contact with the waste piles, and leaching of contamination beneath Building #9 flushed arsenic into the groundwater beneath the plant site. The contaminated groundwater subsequently discharged into the Blackwater Branch and was distributed downstream in the Maurice River drainage system. Currently, the amount of arsenic entering the Blackwater Branch from groundwater discharge off the plant site has been estimated to be approximately 6 metric tons per year (Draft Plant Site Remedial Investigation (RI)).

In response to a series of Administrative Consent Orders issued by the NJDEP (some as early as 1971), ViChem instituted some clean-up actions and modified their production process in 1979. Modifications to the production process included installing a non-contact cooling water system and lining two of the lagoons (Appendix A, LL-1 and LL-2). The clean-up actions included stripping the surface soils in the manufacturing area and paving that area, installing a storm water runoff collection system, disposing of the piles of waste salts, and

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installing a pilot waste water treatment system (which became operational in 1980). This treatment unit treated process water and arsenic-contaminated groundwater pumped from on-site wells. Treated water was discharged back to the aquifer via the unlined lagoons.

The pilot treatment system implemented by ViChem was found to be ineffective by the NJDEP - Division of Water Resources. In fact, the treatment plant effluent and discharges of non-contact cooling water to an infiltration lagoon may have increased the spread of arsenic in the groundwater and accelerated the movement of contaminated groundwater to the Blackwater Branch. Evidence from sampling data taken by the NJDEP in the late 1970s and early 1980s suggested that a serious groundwater contamination problem existed at the ViChem site and that contaminants were migrating off-site into the Maurice River drainage system. Results of NJDEP investigations showed that elevated arsenic concentrations in surface waters and sediments extended as far as 26 river miles downstream of the plant to the Delaware Bay. Union Lake, an 870-acre impoundment on the Maurice River (8 miles downstream of the ViChem site), was shown to impound and store arsenic-contaminated sediments (Draft Plant Site RI).

Because of inadequate safety measures at the plant, a ViChem employee was diagnosed as having subacute arsenic poisoning in 1982 (Draft Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA) for Vineland Chemical). As a result, the New Jersey State Department of Health (NJSDH) conducted an evaluation of arsenic exposure and toxicity at the plant. Study results showed that ViChem employees had elevated concentrations of arsenic in their blood and urine, but exhibited only minor symptoms associated with arsenic trioxide dust on the skin and mucous membranes. The draft RFA states that, as a result of the NJSDH study, the arsenic handling practices at the site have improved.

In 1982 ViChem applied for RCRA and New Jersey Pollutant Discharge Elimination System (NJPDDES) permits to continue to use the lagoons for the discharge from the waste water treatment unit and to discharge non-contact cooling water. For a number of reasons (including that the treatment facility was unable to consistently reduce the discharge below an interim target level of 0.7 mg/l), the State of New Jersey initiated actions to deny the permits. In November 1985, ViChem lost its interim status under RCRA and was ordered to stop placing hazardous wastes into the two RCRA-regulated lined impoundments. In February 1986, ViChem filed a petition with the Court of Appeals for a review of EPA's decision. Reportedly, all of the water currently used in manufacturing the herbicides is consumed by the process and is included as inherent moisture in the product.

The Remedial Investigation (RI) and Feasibility Study (FS) tasks were subdivided into three areas of study: (1) the ViChem Plant Site, (2) Union Lake, and (3) the Rivers Area, which includes Blackwater

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Branch and the Maurice River (except for Union Lake) from the plant site to Delaware Bay. The three RIs encompass a study area approximately 38 miles long. The Draft RIs for Union Lake, the Plant Site, and the Rivers Area were submitted in June, July, and September 1988, respectively. The Draft FSs for the Plant Site and the Rivers Area were issued in October 1988. The Union Lake FS is in progress.

Union Lake, a man-made lake near the town of Millville, is used extensively for recreational activities. The lake has been purchased by the Green Acres Program of the NJDEP, and, currently, the earthen dam at the southern end of the lake is being rebuilt to remedy embankment instability. An inadequate spillway has been demolished, and construction activities are currently under way to construct a new spillway and downstream channel. During reconstruction, the water level of the lake has been lowered approximately 8-9 feet, resulting in exposure of 50-105 acres of lake sediment particularly within the northern sections of the lake. As stated previously, the lake has been shown to impound and store arsenic-contaminated sediments.

In an April 1987 memorandum, the Region II EPA requested that ATSDR provide an early Health Assessment of the Union Lake portion of the ViChem NPL site to assess the potential public health issues relating to drawdown conditions. This memorandum cited the use of the lake as a recreational area and provided water, sediment, and biota data to be used in the Health Assessment. In a health consultation, the results of which were subsequently issued in June 1987, ATSDR concluded that the exposure to sediments during drawdown conditions does not present a significant opportunity for excessive exposure to arsenic nor are the exposed sediments a threat to public health by any route of exposure. However, a risk assessment conducted by the NJDEP in April 1987 (Risk Assessment for Recreational Use of Union Lake) concluded that exposure pathways from both Union Lake sediment and water during drawdown conditions are potential public health concerns. This study noted that acute, subchronic, and chronic exposure to these sediments could lead to toxic (including cancerous) effects. Based on the conclusions of this risk assessment, recreational activities in the lake have been restricted during drawdown conditions by the NJDEP in conjunction with the Cumberland County Health Department. This closure will be in effect until the new dam is installed and the lake returns to its former level.

The RIs include data from bench scale treatability tests for the purpose of assessing the feasibility of various remedial actions in the contaminated areas. Chemical fixation and extraction tests were performed on the contaminated soils and sediments. The fixation test was performed to determine if arsenic in the sediment or soil could be chemically stabilized or physically bound to the sediment such that leachable arsenic concentrations were less than 5 mg/l (the EP RCRA toxicity test threshold). The extraction test was performed to

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determine if arsenic could be removed from the sediment or soil to a concentration of 20 mg/kg, the NJDEP action level. From the treatability studies, both chemical fixation and extraction were determined to be feasible methods to treat the arsenic-contaminated sediments and soils. If these treatment methods are successful, these arsenic-contaminated media could be considered nonhazardous and could possibly be disposed of in a nonhazardous waste landfill after formal delisting. Three treatability tests were performed on contaminated groundwater: adsorption, ion exchange, and reverse osmosis. The groundwater tests were conducted to determine if arsenic could be removed from pretreated groundwater to achieve levels below 50 ug/l, the Federal Primary Drinking Water Standard for arsenic. Again, these technologies were shown to be feasible remedial methods.

B. SITE VISIT

A site visit was made by a representative of ATSDR headquarters and the site assessment team from the Office of Risk Analysis at Oak Ridge National Laboratory on August 25, 1988. This visit was conducted to identify visual evidence of contamination and environmental migration pathways and to determine if humans are at risk from exposure to site-related contamination. During the site visit, areas of special interest were the plant site and nearby residential areas, Blackwater Branch, the Almond Road Bridge area on the Maurice River, and Union Lake, specifically the public beach on the southeastern side of the lake. No arrangements were made with ViChem to tour the on-site areas; however, the lagoon area and the former outdoor storage areas near Ebasco Well (EW) clusters EW-14 and EW-15 (Appendix A) were observable from Wheat and Mill Roads.

A security perimeter fence surrounds the main part of the plant, including the manufacturing buildings and the lagoon area. The remainder of the site is unfenced and is easily accessible by the public. During the visit, partially burned wood from a campfire and other debris, such as food wrappers, were observed in the area north of EW-12, suggesting that persons had trespassed on ViChem property.

Residential areas are adjacent to the plant site on the east, west, and south. There are also residences approximately 150 feet to the north-northeast of the plant, across Wheat Road. Two of the residences on the west side of the plant appeared to be vacant, and information from the NJDEP indicate that these residences are among four residences owned by ViChem (Appendix A). These lots are contiguous with the ViChem property and are considered to be on-site. Martex Inc., an active manufacturing company, is adjacent to the ViChem site, just northwest of the lagoon area.

The water level in Union Lake has temporarily been lowered to repair the earthen dam and to construct a new spillway, resulting in the exposure of lake sediments that would normally be underwater. During

the site visit, the public beach area on the southeastern side of Union Lake was toured. Vehicular access to the beach was restricted; however, the area was easily accessible on foot. A family, including two children, were observed on the beach wading in the water. They had entered the area despite warning signs posted by the NJDEP. These signs stated that the area was closed because of arsenic contamination. The information was also written in Spanish and included an NJDEP telephone number. A playground area adjacent to the public beach remains open for public use. Several residences north of the public beach have lake front property, and a Yacht Club maintains property in this area.

A U.S. Geological Survey (USGS) weir on the Maurice River near the Almond Road Bridge has also been shown to impound and store arsenic-contaminated sediments. A public park and picnic area is near the weir, and the area is locally popular for swimming and recreation. In 1979, recreational activities were restricted in this area because of concerns about exposure to arsenic contamination. In June 1988, the area was reopened when, after completing a risk assessment (Risk Assessment for Recreational Use of West Side Park, May 1988), the NJDEP concluded that, at present levels, analysis of the health consequences of arsenic exposure during normal recreational activities at West Side Park does not demonstrate a significant short-term or long-term health risk. During the site visit, numerous children were observed playing in the water immediately south of the Almond Road Bridge.

C. PUBLIC CONCERNS

In 1983, after the ViChem site was added to the NPL, EPA implemented a community relations program to inform area residents about the Superfund-related activities and obtain their input. The major community concerns related to exposure to contamination are:

- (1) human health risks from exposure to contaminated groundwater because some of the residents rely on groundwater for potable water
- and (2) human health risks from exposure to contaminated surface water because local rivers and lakes are used for recreation.

The NJDEP Division of Science and Research, the NJDEP Bureau of Community Relations, and the Cumberland County Health Department are also involved in community relations concerning the ViChem site.

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ENVIRONMENTAL CONTAMINATION AND PHYSICAL HAZARDS

A. ON-SITE CONTAMINATION

Activities for the Plant Site RI were conducted in two phases. A Phase I site reconnaissance took place in 1986, and Phase II was conducted throughout 1987. During both phases, surface water and sediment samples were also obtained from the Blackwater Branch, and in Phase II surface soil samples were also collected from nearby residences. For the purposes of this Health Assessment, data from the Blackwater Branch, the residences, and from off-site monitoring wells will be assessed in the Off-Site Contamination Section, which also addresses data from the Rivers Area and Union Lake RIs

In Phase II, 36 monitoring wells (Ebasco wells (EW)) were installed and samples were collected from these wells and 11 existing wells (ViChem monitoring wells (MW)). Surface and subsurface soil samples were also obtained, as were dust samples from the former chicken coops and surface water and sediment samples from the lagoons.

Analyses of these samples revealed significant on-site contamination. Contaminants of concern and the corresponding concentration ranges are tabulated in Appendix B according to contaminated media. The data presented are from the 1987 sampling event because these data more likely represent current conditions.

Groundwater

At the ViChem site, groundwater is distributed between two aquifers, a water table aquifer and a deeper, "confined" aquifer. The water table aquifer contains a discontinuous clay- and silt-rich low permeability layer called the "banded zone." The area above the banded zone is referred to as the upper sand. Monitoring wells installed during the RI were screened at various depths to assess the vertical extent of contamination. The shallow wells (EW-S) were screened approximately 5 feet above to 10 feet below the top of the water table; the medium wells (EW-M) were screened at the top of the banded zone; the lower wells (EW-D) were screened below the banded zone. EW-5D and the previously installed Hart well and ViChem production well are below a thick, grey to black, silty sand and clay layer that divides, but may not prevent hydrologic communication between the water table aquifer and the deeper aquifer.

As shown in Appendix B, the groundwater beneath the plant site is contaminated. Arsenic contamination is pervasive in the shallow portion of the water table aquifer, reaching a maximum of 12,600 ug/l in EW-8S. Well cluster EW-8 is near ViChem's MW-1 which had an arsenic level of 26,500 ug/l in 1986. In the 1987 sampling event, the arsenic concentration in MW-1 had dropped to 8,730 ug/l. EW-8S also

revealed the maximum on-site concentrations of antimony, cadmium, and lead, making this area the most contaminated part of the aquifer. In general, most of the shallow well metal contamination was found in the well clusters that are located in and around the lagoon area. The maximum shallow well trichloroethene contamination was found in EW-14S near the former outdoor storage area (Appendix A).

Although the areal extent of the contaminant plume is larger in the shallow part of the upper sand, the wells screened in the lower part of the upper sand (above the banded zone) have the highest contaminant concentrations. (Conductivity data indicate that, at least in the near surface, arsenic contamination may have been diluted and flushed by surface recharge.) Maximum concentrations of arsenic, cadmium, lead, and trichloroethene in on-site groundwater were found at this depth, with contaminant maximums generally seen in the northern and northwestern areas of the plant. Arsenic and cadmium in EW-7M were at concentration levels of 15,800 and 623 ug/l, respectively; trichloroethene was at a concentration of 260 ug/l in EW-14M, and the lead concentration increased to 110 ug/l in EW-15M from 3.9J in EW-15S.

The lower portion of the water table aquifer (below the banded zone) is less extensively contaminated (in areal extent) and has lower concentration levels than the upper and middle portions. Of the wells screened in this interval, EW-15D contains the highest concentration of arsenic at 28 ug/l. The highest concentrations of cadmium and lead were found in EW-9D, which is located in the northeast corner of the plant site. EW-12 (considered to be an upgradient well cluster) did not contain detectable concentrations of arsenic.

Three on-site wells are screened in the deep aquifer below the clay layer that characterizes the base of the water table aquifer. These include the plant's production well, EW-5D, and the Hart well located in the lagoon area. Because contaminant levels were almost always below detection limits in this interval, groundwater contaminant concentration ranges in the confined aquifer are not given in Appendix B. Of the contaminants of concern, only antimony (at a concentration of 330 ug/l) in EW-5D was found above detection limits in the deep aquifer.

Surface soil

Surface soil samples collected from the plant site showed metals contamination. Surface soil from the upper 2 feet of the unconsolidated zone was retrieved from 108 locations at the plant site, and several soil borings conducted during the RI also included sampling an interval 2 feet below the ground level. Arsenic was detected in 90 out of 108 surface soil samples; however, only 24 samples had arsenic concentrations greater than 20 mg/kg, the NJDEP action level. Elevated concentrations of arsenic, lead, and mercury

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were seen in both the fenced and unfenced areas of the plant site, more specifically, in the area by EW-14, in the lagoon area, on the east side of the manufacturing area, in the clearing by well cluster EW-15, and in an area approximately 250 feet southeast of the ViChem production well. Mercury contamination was predominately localized in the lagoon area. Levels of cadmium, antimony, and trichloroethene in surface soil samples were below instrument detection limits.

Subsurface soil

Soil borings were conducted with samples taken at 2-foot intervals to the water table. Soil samples were also taken from the monitoring well borings at 2-foot intervals to the water table and at 10-foot intervals thereafter. Only a few of the soil boring samples displayed elevated concentrations of metals, and these were in the same areas where surface soil contamination was seen. In general, when contamination was seen, it was highest at the surface and decreased with depth. Most of the soil borings displayed low or undetected arsenic concentrations; the arsenic subsurface soil contamination is apparently a fairly localized phenomenon.

The monitoring well soil samples show that the soil below the water table generally had very low arsenic concentrations. Arsenic was not detected in well cluster EW-1, across the Blackwater Branch from the site, throughout its depth to approximately 110 feet. The same is true of cluster EW-12, upgradient of the site. Cluster EW-9, also upgradient of the lagoon area, had very low arsenic concentrations below the water table but had noticeable concentrations above the water table. This may be caused by the surface application of arsenic-containing herbicides at this location (Draft Plant Site RI). When arsenic was detected in the soil below the water table, it was generally near the top of the banded zone. Very little arsenic was detected in the soils below the banded zone. Only well cluster EW-7 showed elevated arsenic concentrations throughout the soil column to the banded zone. As in the surface soil data, most of the contaminants of concern were below instrument detection limits.

Localized on-site areas

Crystalline arsenic wastes were reportedly seen in soils below Building #9 before a concrete floor was installed, and data from five soil borings reveal that arsenic concentrations are very high beneath the floor of this building. This building remains in use, and the floor is currently composed of one layer of brick over approximately one foot of concrete. The underlying soil is essentially capped by the building and surrounding pavement. Therefore, the significance of the contamination is associated with leachate production from the soil as the water table rises and falls.

One composite dust sample was taken from each of the four former chicken coops located at the plant site. The principal inorganic chemicals found in the samples were arsenic, cadmium, lead, and mercury. Coop #3 exhibited the highest concentrations of these metals and is the only coop presently used to store process chemicals. Information gathered in 1987 as part of the Plant Site RI revealed that one resident near the plant area houses chickens in one of the rooms of coop #4. This activity does not represent a poultry farming operation.

Water samples were taken from the two lined lagoons and from the unlined lagoon, UL-A. Reportedly, only non-contact cooling water and treated water are currently discharged into UL-A; however, all of the lagoons were previously used to hold the formerly untreated process water. Arsenic was either not detected or was detected only at very low concentrations in the water samples obtained from the unlined lagoon. Arsenic was detected at concentrations up to approximately 3,500 ug/l in the water samples from the lined lagoons. Sediment in UL-A was also sampled, and arsenic was found at concentrations up to 185 mg/kg.

B. OFF-SITE CONTAMINATION

For the three RIs, water, sediment, and biota samples were collected from area surface water bodies. Monitoring wells installed for the Plant Site RI included three clusters (EW-1, EW-2, and EW-4) that are considered to be off-site (Appendix A). Analyses of samples from these wells and other off-site areas generally reveal lower contaminant concentrations than samples collected on-site; however, off-site contamination covers a much larger area. The contaminants of concern identified in on-site data are listed in Appendix C along with their concentration ranges in off-site media.

Groundwater

The groundwater data presented previously in the On-Site Contamination Section showed a significant arsenic plume migrating to the north and northwest of the plant site toward the Blackwater Branch. No arsenic contamination was detected at any depth in well cluster EW-1, which was installed across the Blackwater Branch. The available data show that arsenic contamination in the shallow groundwater apparently discharges into the Blackwater Branch and does not cross under the stream. EW-2 and EW-4, however, lie south of the Blackwater Branch and intercept the arsenic plume before its discharge into the branch. These wells showed elevated levels of arsenic in EW-4S and 394,000 ug/l in EW-4M. Cadmium contamination was also found in EW-4M at a concentration of 9,580 ug/l, and lead concentrations were found as high as 65.2 ug/l in EW-2M. Except for arsenic, only lead at a concentration of 97 ug/l was found above detection limits below the banded zone.

Surface soil

Surface soil samples were collected from 13 residences in the vicinity of the plant. The arsenic concentrations in these samples ranged between 0.9 and 78 mg/kg, and only one of the 14 samples had an arsenic concentration which exceeded 20 mg/kg, the NJDEP action level. The highest concentration was found in a sample collected at a residence southwest of the plant, and the second highest concentration (12 mg/kg) was found in a sample collected at one of the residences along Wheat Road, northeast of the plant.

Subsurface soil

Subsurface soil samples were taken during the installation of well clusters EW-1, EW-2, and EW-4. Most of the contaminants of concern were not detected in these samples at concentrations above detection limits. Exceptions were arsenic and lead, which were found in EW-2M at concentrations of 61.4 and 23 mg/kg, respectively. Arsenic was also found at 59 mg/kg in EW-4M.

Blackwater Branch surface water and sediment

Surface water and sediment samples were collected from the Blackwater Branch at the locations shown on Appendix A. Ebasco River (ER)-3 is considered to be upstream of the plant site, and samples collected from this location generally showed low or undetectable concentrations of the contaminants of concern. However, lead was found in both the surface water and sediment at ER-3, suggesting that the elevated levels of lead found in the groundwater at EW-9D might be a source for this contaminant (Appendix A). Surface water and sediment samples from both stations downstream from the site (ER-4 and ER-3A) revealed arsenic contamination at maximum concentrations of 6,200 ug/l and 12,800 mg/kg.

Maurice River surface water, sediment, and biota

Surface water, sediment, and biota samples were collected from the Maurice River from its confluence with the Blackwater Branch to where it empties into Union Lake and from the spillway from Union Lake to the river's mouth at Delaware Bay. Samples were also collected at a location (ER-6)¹ above the Blackwater Branch confluence to assess if any upstream sources were contributing to the contamination in the river. Almost all of the contaminants of concern were at undetectable levels in both surface water and sediment from ER-6. Only lead was found to exceed detection limits in sediment and surface water above the confluence. Samples were also collected from three other tributaries that empty into the Maurice River above Union Lake. Again, metals were found above detection limits only at low concentrations.

¹ Sample locations correspond with maps in the RIs

From the Blackwater Branch confluence to Union Lake, the Maurice River sediments and surface water exhibit mainly arsenic contamination. Generally, the highest surface water arsenic concentrations were found near the confluence and decreased south to Union Lake. ER-5 at the Blackwater Branch confluence revealed the highest surface water concentration at 570 ug/l. However, ER-9F, which is located approximately 5-6 miles below the confluence, revealed the highest sediment concentration at 922 mg/kg. Three fish species were collected from the river approximately 1.5 miles below the confluence at ER-8 and were composited into three samples for analysis. Only one composite sample, the black bullhead, contained a detectable level of arsenic in its tissue at .91 mg/kg.

Surface water, sediment, and biota samples were also collected in the Maurice River from the Union Lake spillway to the Delaware Bay. Surface water samples were analyzed for metals; sediment samples were analyzed for arsenic; biota samples were analyzed for arsenic, pesticides, and polychlorinated biphenyls (PCBs). Concentration ranges were lower than those found in the Maurice River above Union Lake. Arsenic contamination in surface water decreased uniformly with increasing distance and dropped below 50 ug/l around the town of Port Elizabeth, approximately 10 miles below Union Lake. Arsenic levels in sediment also decreased to the south with a maximum concentration of 234 mg/kg at ER-22 (approximately 5 miles below Union Lake). The arsenic concentration in sediment did not decrease uniformly downstream: the sediment arsenic distribution is more likely controlled by arsenic's chemical partitioning to fine-grained material and by the local deposition rate than by strict distance downstream from the source. Fish and other aquatic animals were collected from this segment of the Maurice River and from Delaware Bay. The fish samples did not reveal detectable arsenic concentrations; tissue from crabs and oysters revealed arsenic concentrations up to 1.6 mg/kg, which is generally within the range of normal background levels in shellfish.

Union Lake surface water, sediment, and biota

Surface water, sediment, and biota samples were also collected from Union Lake during the RI. Results of previous studies by the NJDEP and Rutgers University had shown that the water and bottom sediments of Union Lake were contaminated with arsenic (range - 28 ug/l to 78 ug/l), and that total arsenic concentrations in most lake water samples exceeded the NJDEP and EPA drinking water standard of 50 ug/l (Faust, et.al., 1983). The Union Lake RI sampling confirmed this contamination, and almost all water samples collected exceeded 50 ug/l (Appendix C). Data collected by the southern enforcement office of the NJDEP indicated that arsenic levels in Union Lake water fluctuate around 50 ug/l. The exact level of arsenic depends on the time of the year (winter vs. summer) and ranges between 40 and 100 ug/l (New

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Jersey Department of Environmental Protection, letter to New Jersey Department of Health, March 31, 1989). The studies by the NJDEP and Rutgers also included speciation of trivalent arsenic (As^{+3}), pentavalent arsenic (As^{+5}), monomethyl arsenic acid (MMAA), and dimethyl arsenic acid (DMAA). In water, the order of predominance of species was: MMAA, As^{+3} , As^{+5} , and DMAA. Trivalent arsenic concentrations tend to be higher in the summer.

The highest arsenic concentration in water was found in the northern part of Union Lake where the Maurice River emptied into the lake and near an old submerged dam that probably causes a localized impoundment of arsenic-contaminated sediment and surface water. Other metals were found above detection limits, but at low concentrations in the water. In general, the dissolved arsenic concentrations were uniform throughout the water column. Particulate and/or total aqueous arsenic concentrations tended to be higher in water samples taken at the sediment/water interface.

Samples were also collected of both surface and subsurface sediments in Union Lake. Arsenic contamination within the Union Lake sediments appears to be a surficial phenomenon. Data from sediment cores revealed a high surface sediment arsenic concentration of 636 mg/kg near the southwestern shore of the lake. This area is now exposed because of the drawdown conditions during spillway remediation. In August 1986, sampling by the NJDEP revealed that the highest levels of sediment contamination are generally restricted to the top one foot of the sediment and are found in the northern section of the lake. During this sampling event, arsenic concentrations ranged from below detection limits to a maximum of 1,273 mg/kg. Elevated levels were also found adjacent to the main dam in the southern portion of the lake. Arsenic concentrations in sediment at the bottom of Union Lake were as much as three orders of magnitude higher than in the overlying waters. Speciation of arsenic in the sediments revealed the following order of predominance: As^{+5} , As^{+3} , MMAA, and DMAA. Fish samples from Union Lake were also analyzed for arsenic, and the concentrations found in these samples are given at the bottom of Appendix C.

C. PHYSICAL HAZARDS

No physical hazards were observed in any of the on-site or off-site areas.

DEMOGRAPHICS OF POPULATIONS NEAR THE SITE

A. POPULATIONS AT RISK

Residential areas are located on all sides of the ViChem plant site, with the closest residences adjacent to the plant on its western boundary. Residential lots to the south and east are also contiguous with the plant property but are located farther away from the main manufacturing area. Residences to the northeast are approximately 150 feet from the plant, across Wheat Road. The residences in the vicinity of the plant have small-to-medium-sized yards, and some have backyard gardens.

Numerous towns and villages are close to the Maurice River, and according to 1980 census information, approximately 80% of the population (or 9,251 persons) in the surrounding rural townships reside within 1 mile of the river. Union Lake is located on the Maurice River in the northeast quadrant of the city of Millville (population 24,815). About 25 homes front the lake, and an additional 110 homes are clustered on the eastern side of the lake, northeast of the dam and within one-half mile of the lake. The Union Lake Sailing Club, which operates a facility in this area, has a membership of approximately 200 families.

Of the populations in the vicinity of the plant site and the area surface water bodies, three subgroups may be at special risk from exposure to site contamination. Previous evaluations of arsenic exposure at the site revealed that ViChem personnel had elevated levels of arsenic in their blood and urine and exhibited symptoms associated with irritation of the skin and mucous membranes. This known past exposure of ViChem personnel could increase the risk potentially posed by current and future exposure to on-site contamination. Since this exposure evaluation, proper handling methods and safety precautions have reportedly been implemented. People who use the Maurice River and Union Lake for both recreation and as a source of edible fish have an increased frequency of exposure and, thus, an increased risk from exposure. Although PCB contamination is not associated with the ViChem site, fish used for consumption represent an exposure risk because of PCB levels in their tissues. Finally, the children observed at Union Lake and the Almond Road area may be at greater risk because of their recreational activities and their sanitary habits, which increase their probability of exposure to off-site contamination.

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B. LAND USE

The city of Vineland is classified as urbanized, and the area surrounding the plant site is partly residential and partly industrial. Commercial and industrial development near the plant site is expected to increase in the near future with the completion of New Jersey State Route 55 in the area.

Blackwater Branch is not currently used for recreational purposes; however, a city park is located approximately one-half mile downstream from the confluence of the Blackwater Branch and the Maurice River at the Almond Road Bridge. This area is a favorite local recreational site. Lands immediately adjacent to the Blackwater Branch and the Maurice River constitute a floodplain.

The city of Millville is classified as an urban center/rural community. The Millville Parks Department manages Union Lake Park, which provides access to the Union Lake beach and other lake-related activities. The beach is located at the southern end of the lake and has a waterfront of approximately 400 feet. The Parks Department estimates that a maximum of 400 people use the beach on a hot day. Union Lake has an 8.5 mile shoreline and is almost entirely surrounded by coniferous forest, woodland, and open space. Land use in the vicinity of the lake primarily involves recreational activities, such as hunting, fishing, boating, and hiking.

EVALUATION

A. DATA NEEDS AND EVALUATION

1. Environmental Media

Data are insufficient or lacking for the following media at the ViChem site: off-site groundwater and chickens housed on-site in one of the chicken coops.

Results of the hydrogeologic investigation at the plant site showed that groundwater movement in the area had both northern and western components. The westernmost on-site wells, EW-10 and EW-13, showed both arsenic and cadmium contamination. The nature and extent of groundwater contamination farther to the west across Mill Road should be assessed, since commercial and industrial development near the plant site is expected to increase in the future.

The hydrogeologic investigation also showed that groundwater in the upper aquifer discharged into the Blackwater Branch, and sampling of the well cluster north of Blackwater Branch (EW-1) confirmed that

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contaminated groundwater had not migrated under the branch in that localized area to the northwest of the plant site (Appendix A). However, additional monitoring wells should be installed north of Blackwater Branch and approximately due north of the lagoon and manufacturing areas to confirm that contamination (found at greater depths in the aquifer) from these heavily contaminated areas is not migrating farther to the north.

The former chicken coops on-site have historically been used to store raw chemicals used in ViChem's manufacturing process. Only coop #3 remains in use for ViChem storage; however, portions of the other coops are used for domestic storage. Information gathered in 1987 as part of the Plant RI revealed that one resident near the plant area houses chickens in one of the rooms of coop #4. More recent information from NJDEP suggests that this activity no longer occurs (NJDEP, letter to NJDOH, March 31, 1989); but this was not verified. Analyses of dust samples from the coops revealed metals contamination. Ingestion of this contamination by the chickens could result in food-chain contamination. Although this activity is small scale and does not represent a poultry farming operation, without data, this potential environmental pathway cannot be adequately assessed.

2. Demographics and Land Use

All of the residences located downgradient of the plant site have access to the Vineland municipal water supply; however, three lots to the west of the plant site are not metered according to the water supply district. Two of these lots contain houses, and residents at these homes may use private wells as their drinking water source. These lots are generally upgradient of the groundwater contamination at the plant site, and associated private wells are unlikely to intercept any contaminated groundwater. In the Draft Plant Site RI, the metered residences were assumed to have used the municipal supply for their potable supply, but whether private water wells were used for other domestic purposes was not known. A survey of water-well use should be conducted in the residential area west of the plant site to assess possible exposure to contaminated groundwater.

3. Quality Control (QC) and Quality Assurance (QA)

Overall, the data presented in the RIs were relevant and representative and were adequate to accomplish the purposes of this Health Assessment. Further sampling of groundwater in off-site areas, food-chain contamination data, and a survey of water-well users in the area just west of the plant site would allow the health implications posed by site contamination to be more completely assessed.

Samples collected for the three RIs were analyzed and validated by EPA's Contract Laboratory Program (CLP). These analyses were considered confirmational level, the highest level of data quality. Use was also made of data obtained before the RIs were performed. Although the chemical analyses presented in many of these previous studies may not have been performed to the same QA/QC standards as the

samples taken for the RIs, the locations of contamination and contaminant fates as determined by these studies were fully supported by CLP data.

B. ENVIRONMENTAL PATHWAYS

Several environmental pathways have been identified for the ViChem site. These pathways and their relationship to contaminated media are discussed below, along with site-specific and chemical-specific factors that can either enhance or retard contaminant migration.

Groundwater

The Vineland area is underlain by a thick sequence of sand units with clay- and silt-rich interbeds. Groundwater is distributed between two aquifers in these units, a water table aquifer and a deeper aquifer, which is used regionally as a drinking water source. The two aquifers are separated by a low permeability, clay-rich layer. However, in many places this layer contains silt and fine sand, and results of pumping rate studies conducted during the Plant Site RI indicate that the aquifers are not totally isolated from each other.

The water table aquifer beneath the plant site is approximately 120 feet thick and is approximately 6 feet below the ground surface. Flow in this aquifer is generally to the west toward the Maurice River, with a localized northern component to Blackwater Branch at the plant site. The flow rate in the upper part of this aquifer ranges from 2-5 feet per day. The water table aquifer contains a discontinuous low permeability layer called the "banded zone." This zone, an interval of interbedded clastics with clay laminations, is located between 38 and 77 feet below the ground surface. Although the banded zone does not prevent the vertical movement of groundwater, analytical data indicate that there is extensive groundwater contamination above the banded zone, but very little below it, suggesting that the clay laminations essentially act as contaminant traps.

Water levels in the water table aquifer are higher than in the Blackwater Branch, resulting in an upward hydraulic gradient. It is not known if the area below the banded zone is hydraulically connected to the Blackwater Branch, but the shallow groundwater above this zone appears to be recharging the branch near the plant site. Although a component of the water table aquifer may flow underneath the Blackwater Branch, no significant contamination has been detected in the groundwater across the branch. Analytical data from Blackwater Branch upgradient of the plant site indicate virtually undetectable concentrations of most of the contaminants of concern, confirming that groundwater recharge from the plant site is responsible for the contamination in the Blackwater Branch. In the absence of site-specific data, it is impossible to determine whether the Maurice

River is influent or effluent at all points along its length. However, the available data suggest that this river is also recharged by the groundwater.

Of the contaminants of concern, only arsenic has been consistently found at elevated levels in surface water from the Blackwater Branch. Without remediation of on-site groundwater, arsenic concentrations in Blackwater Branch are likely to remain high, since the wells closest to the branch contain very high arsenic concentrations. Although cadmium and antimony contamination has not been found in Blackwater Branch, elevated levels of these metals in on-site groundwater suggest that groundwater contaminated with these parameters has not yet reached the branch. Also, trichloroethene in on-site groundwater may migrate rapidly to the discharge area because of the low percentage of fine-grained material and the low organic carbon content of the soil that preclude its adsorption and persistence. However, any trichloroethene near the surface may volatilize through the surface soil and, thus, may not reach the Blackwater Branch in significant quantities. Should these contaminants reach the Blackwater Branch, the metals will probably be bound to the suspended matter and eventually settle to the branch bottom, and trichloroethene may partially volatilize to the atmosphere.

The deep aquifer is contained within a medium-to-fine-grained, relatively dense sand unit. This aquifer is used both locally and regionally as a source of drinking water and for manufacturing purposes. The ViChem production well, the Hart well, and EW-5D are screened in this aquifer. Although studies indicate that the water table and deep aquifers may be interconnected, groundwater data from these three on-site wells have not revealed significant contaminant concentration levels.

Soil

Arsenic is relatively mobile in the environment; however, arsenate salts are readily formed on the surfaces of soil and sediment materials. Because arsenic is a phosphorus analog, it undergoes similar transformation and biogeochemical cycling, though rates of transformation may differ. Arsenic in soil material has been shown to be associated with increased organic content and/or an increased percentage of silt and clay content in the soil. Although arsenic has been shown to desorb from soil particles during reducing conditions, studies by Elkhatib, et. al. (1984) and Winka (1985) (these studies are referenced in the Draft Plant Site RI) indicate that a fraction of the adsorbed arsenic appears to be irreversibly bound to the soil or sediment material. More specifically, these studies revealed that adsorption of arsenic to sediment is not an entirely reversible process, and that soil/sediment material may act as a sink for arsenic.

Adsorption onto soil and sediment particles is also an important mechanism in the fate and transport of mercury in the environment. The lack of measurable mercury in the site groundwater and its concentration in on-site surface soils confirm the high adsorption concept.

Resuspension and subsequent downwind deposition of contaminated soil may have occurred near the plant site, since residential surface soils in the vicinity of the plant had an arsenic concentration range of 0.8 to 78 mg/kg. However, arsenic is a component of many household weed killers, and these levels may not be attributable to the ViChem site. If resuspension of contaminated soil from the plant site has contributed to the contamination of the nearby residential area, this migration pathway is probably not as significant currently as it has been historically since the waste piles have been removed from the site and the area surrounding the manufacturing buildings has been paved. However, any future remedial action that involves soil-disturbing activities may augment migration via this environmental pathway, and proper dust control procedures should be implemented when necessary.

Leaching of contamination from the surface and subsurface soils is enhanced by the high percentage of sand in the soil, which encourages infiltration of surface water rather than overland flow. The subsurface soil just above and below the water table is probably most heavily leached because of fluctuations in the elevation of the water table.

Surface Water

Surface water flow over contaminated soil or sediment may remove contaminants in both dissolved and particulate form. The sandy nature of the soil inhibits overland flow; however, in steeper areas near the plant site (i.e., the banks of the Blackwater Branch), surface water flow is more likely to occur.

Infiltration of surface water to groundwater reservoirs is greatly enhanced in the lagoons that collect water. This migration pathway is significant since the lagoon area was used to dispose of untreated waste water for several decades and currently represents one of the most contaminated on-site areas. One of the unlined lagoons presently receives treated process water and non-contact cooling water discharge from the manufacturing process. This water is allowed to percolate into the soil.

Currently, surface water flow in off-site drainage channels (the Blackwater Branch and the Maurice River above Union Lake) basically behaves as a conduit, transferring the arsenic contamination downstream into Union Lake. This has not always been true, however, as sediments in the drainage channels show elevated concentrations of arsenic caused by adsorption of the contaminant from surface water.

The rate of dissolution of arsenic increases with increasing salinity in the portion of the Maurice River below Union Lake. This is largely related to the salt intrusion from Delaware Bay. With the intrusion comes a range of ions which can form insoluble salts with arsenic removing it from solution (Draft River Areas RI).

Arsenic concentrations in surface water drainage channels generally diminish with increasing distance from the plant site. Contaminant concentrations are diluted by the combined effects of water upstream from the Blackwater Branch confluence, tributaries that enter the Maurice River below the confluence, and overland flow to the river.

Surface water arsenic concentrations in Union Lake may reach maximum levels during and following hydrologic events which act to resuspend bottom sediments. Such events could include naturally occurring seasonal lake turnover or storm events. They could also include artificially induced hydrologic events, such as abrupt draining and filling of the lake.

Sediment

Soils on the banks of Blackwater Branch and the Maurice River are predominately sandy, with generally less than 10% silt and less than 10% clay. The organic content of the soils surrounding these drainage channels is increased because of the vegetation that grows near the water supply. In the past, sediments in the channels have adsorbed arsenic from the surface water and, like the on-site soils, have acted as an arsenic sink. Overall, the sediments in Union Lake also act as an arsenic reservoir and sink and are at least partially controlling arsenic concentrations in the overlying waters by desorption. Therefore, regardless of any future influx of arsenic to the lake from the Maurice River, water column arsenic concentrations may remain at their current levels because of the desorption mechanism from the sediments. Maximum water column dissolved arsenic concentrations are likely to occur during summer periods when stratification of the lake occurs and low dissolved oxygen concentrations result in reducing conditions in the bottom sediments. As referenced in the Draft Union Lake RI, studies by the NJDEP and Rutgers University have shown that these anaerobic conditions in the bottom sediments are conducive to the formation of toxic arsenical compounds from the contaminated sediments. The more toxic forms could then be released to the water column upon seasonal turnover of the stratified layers. However, since these compounds are extremely insoluble under the aerobic conditions typically found in the upper levels of the lake, they are expected to precipitate and settle back to the lake bottom within a relatively short period of time. The Rutgers study included the speciation of the arsenic and determined that these species may be transformed by changes in physical condition and season. In

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sediments, the species found (in descending order) were pentavalent arsenic (arsenate), trivalent arsenic (arsenite), monomethyl arsenic acid (MMAA), and dimethyl arsenic acid (DMAA). In water, the order of predominance was MMAA, arsenite, arsenate, and DMAA.

Contaminants from river and lake sediments do not appear to be leaching, since contamination has been shown to occur mainly in the surface sediments. Also, groundwater in most areas recharges surface water bodies; thus, a leaching mechanism probably does not remove contamination from the sediments to the groundwater.

Contaminated sediments that are exposed to the atmosphere could possibly become resuspended and be transported via wind currents. The natural revegetation of the exposed lake bed of Union Lake reduces the potential for resuspension of contaminated lake sediments.

Biota

Uptake of contaminated water and sediment by fish and other aquatic life in the Maurice River and Union Lake could result in bioaccumulation and biomagnification of contamination in the food chain. Evidence found in "Water-Related Fate of 129 Priority Pollutants" (EPA 440/4-79-029a) indicates that inorganic arsenic is bioaccumulated to toxic levels in the tissue of aquatic and marine organisms and has the potential to concentrate in the food chain. In general lower forms of aquatic life accumulate more arsenic residues than fish. The forms of organic arsenic that are bioaccumulated (i.e., arsenocholine and arsenobetaine) are generally much less toxic than other organic (and even inorganic) forms. Also, ingestion and inhalation of contamination by any chickens housed in a room of coop #4 could result in contamination of chickens and eggs used for consumption.

C. HUMAN EXPOSURE PATHWAYS

The potential human exposure pathways at the ViChem site are discussed below according to contaminated media and potentially exposed populations.

ViChem personnel involved in the plant's manufacturing processes may be exposed to contaminants. ViChem currently manufactures the compounds disodium methanearsonate and monosodium methanearsonate. Inadvertent ingestion, dermal absorption, or inhalation of these and other chemicals may occur inside the manufacturing and storage buildings or in the outdoor areas of the plant site where environmental media have been shown to be contaminated. Also, sampling and remedial personnel and trespassers on the ViChem property may be exposed through these same routes, although for shorter durations. Protection measures as defined by the Occupational Safety and Health Administration (OSHA) should be implemented in all

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occupational settings to protect human health. Protection measures implemented according to Health and Safety Plans during any future EPA or state required remedial action should be sufficient to protect short-term contractor personnel.

There is no known consumption of contaminated groundwater either on- or off-site. ViChem currently draws groundwater from the uncontaminated deep aquifer only for use in its manufacturing process. The residential area to the west represents the closest public populations, and most of the homes in this area have been connected to the municipal water supply system since 1968. The two homes not connected to the city water supply are located to the southwest and are generally upgradient of the groundwater contamination. Therefore, private wells at these residences are unlikely to intercept any contaminated groundwater from the plant site. However, it is not known if the downgradient residences that use the municipal supply for potable purposes also use private wells for other domestic uses. Should these residents use groundwater for any other purpose they could possibly be exposed to contamination via inhalation or dermal absorption pathways. These residents also did not have access to the municipal water supply until 1968, whereas ViChem has been in operation since 1949. This suggests that residents immediately to the west of the plant may have been exposed to contaminated groundwater via ingestion. The residential areas to the northeast, east, and south are hydrologically upgradient of the plant site, and populations in this area are not expected to be exposed to contaminated groundwater.

Surface soil in the residential areas near the plant site is slightly contaminated with arsenic. Populations in these areas could possibly incur exposure by ingestion, inhalation, and/or dermal absorption of contaminants.

There is no known use of surface water for drinking water or irrigation. The cities of Millville and Vineland derive their water supplies from wells screened in the deep aquifer. None of these wells are downgradient of contaminated areas, and most are at least one mile from Union Lake. The city of Millville does periodically monitor its public water distribution system for arsenic content. Data for 1988 show that arsenic was undetected in this system at a detection limit of 0.005 mg/l.

Area surface water bodies are heavily used for recreational activities. Populations wading, swimming, boating, or fishing in the Maurice River or Union Lake could be exposed via ingestion of contaminated water, sediment, or biota; inhalation of contaminated particles resuspended by wind currents; or dermal absorption of contaminants in surface water or sediment. According to information from the NJDEP, the area exposed in the northern portion of Union Lake during drawdown conditions has become a popular spot for riding

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all-terrain vehicles. This activity could increase the particulate concentration in ambient air.

PUBLIC HEALTH IMPLICATIONS

Improper waste handling and waste disposal at the ViChem facility have resulted in on-site soil and groundwater contamination and off-site contamination in the water and sediment of the Blackwater Branch, the Maurice River, and Union Lake. Levels of contamination in these media may pose potential health concerns to on-site personnel, remedial workers, and off-site public populations. The exposure pathways and contaminants of concern are summarized below for each of the contaminated media. Currently, the health effects associated with exposure to contaminated chickens/eggs from the a room in coop #4 cannot be assessed because of lack of data.

Because residents near the site along Mill Road may use private wells, the presence of off-site contaminated groundwater and the continued off-site migration of on-site contaminants may present a potential threat to human health. The possibility of past exposure to contaminated groundwater intensifies this concern. Because all residences downgradient of the contaminant plume have access to the municipal water supply, there is low potential that exposure via ingestion to contaminated groundwater is occurring. However, usage of contaminated groundwater for other domestic purposes (i.e., outdoor uses such as water for irrigation or to wash cars) may continue. Thus, exposure to contaminants in the groundwater might be more likely to occur through dermal absorption or inhalation of steams and vapors. Contaminants of concern identified in groundwater are: antimony, arsenic, cadmium, lead, mercury, and trichloroethene (only arsenic and cadmium are currently found at elevated levels in off-site groundwater).

Although some of the contaminants addressed are found at low levels, many of these chemicals induce similar toxicities (e.g., lead, mercury, and trichloroethene all induce central nervous system toxicity); therefore, exposure to multiple contaminants may have synergistic or additive effects, increasing the potential for adverse health effects. The potential for exposure through multiple exposure pathways (i.e., both ingestion and dermal absorption exposure incurred during swimming) may also have additive effects, thereby increasing the potential for adverse health effects. Since longer term exposure is more likely in off-site situations and acute exposure is more likely on-site, symptoms associated with chronic or acute exposures will be emphasized, where appropriate. Of the contaminants of concern, only arsenic and trichloroethene are classified as carcinogenic (human carcinogenicity evidence exists only for arsenic). Lead and mercury are noncarcinogens, and evidence of the carcinogenic potential of antimony has not been evaluated. While

limited data support cadmium's carcinogenicity via the inhalation route, insufficient data exist to classify cadmium as carcinogenic to humans via ingestion. Because cadmium contamination was found predominantly in groundwater and, therefore, cadmium ingestion is more likely, systemic health effects from cadmium exposure will be emphasized. Health effects associated with the contaminants of concern are discussed below relative to possible exposure from all of the contaminated media.

Groundwater and surface water

The chemicals of concern and concentration ranges in area groundwater and surface water are tabulated in Appendices B and C. Although groundwater in the upper aquifer and surface water are not presently known to be used as potable supplies, exposure to contaminated water could occur during other domestic uses, during sampling activities, or during recreational activities in area rivers and Union Lake. Should contaminated groundwater or surface water be used as drinking water, adverse health effects associated with this exposure may occur. Many of the contaminants of concern exceed EPA's primary drinking water standard maximum contaminant levels (MCLs); several exceed the EPA Office of Drinking Water draft health advisories. MCLs and health advisory levels that are exceeded in groundwater and surface water (MCL and health advisory values in ug/l) are:

MCLs: arsenic (50), cadmium (10), lead (50), mercury (2),
trichloroethene (5)

1-day: arsenic (50), cadmium (43)

10-day: arsenic (50), cadmium (43)

longer term (child): arsenic (50), cadmium (5)

longer term (adult): arsenic (50), cadmium (18)

lifetime: arsenic (50), cadmium (5), mercury (1.1)

Health effects associated with exposure to the chemicals of concern in groundwater and surface water are given below. Because antimony, mercury, cadmium, and trichloroethene are elevated only in groundwater and because of the infrequency and short duration of exposure to this medium, health effects attributable only to acute exposure will be emphasized. Because trichloroethene is volatile in aqueous systems, inhalation of this chemical may be a more significant pathway than ingestion. Protective measures as defined by OSHA and guidelines proposed by OSHA and ACGIH should be adequate for protecting human health and should be implemented when worker-related exposure to groundwater may occur.

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Occupational exposures to antimony via inhalation have resulted in discrete clinical health effects, myocardial damage being the best characterized; however, data are not adequate to assess the myocardial effects of antimony ingestion. Exposure to high doses of cadmium may produce severe irritation of the stomach leading to acute gastritis effects and can cause kidney damage. Longer term exposure to low doses of cadmium may also cause kidney damage and as a result of prolonged excess renal-calcium-loss can increase bone porosity and cause skeletal disease. Trichloroethene is a probable human carcinogen and because of its volatility is a common air contaminant. Prolonged inhalation of moderate concentrations causes headaches and drowsiness. Trichloroethene is currently found only in on-site groundwater. On-site workers could be exposed during sampling or remedial activities by inhalation or by dermal absorption (trichloroethene is also a strong skin and eye irritant). Proper monitoring of ambient air and appropriate protective personnel equipment during sampling activities or in future groundwater treatment situations should reduce the inhalation exposure and, thus, the risk from this volatile contaminant.

In occupational settings where arsenic contamination exists, eye, nose, and throat irritations are common. Acute exposure may also result in nausea, vomiting, and diarrhea in sensitive subgroups, such as children. Chronic exposure to arsenic contamination is most likely since it is pervasive in all on- and off-site media. The Carcinogen Assessment Group of the EPA has concluded that there is sufficient evidence that inorganic compounds of arsenic are both lung and skin carcinogens (EPA, 1984). Neurological dysfunction is also common after acute and chronic arsenic exposure and may lead to hearing loss and mental retardation in children. Short-term exposure to maximum sediment levels in the Blackwater Branch, Maurice River, and Union Lake may lead to possible systemic effects in small children playing in and subsequently ingesting arsenic-contaminated water. A very low percentage of arsenic has been shown to absorb through the skin, but dermal contact may lead to dermatitis.

Soil and sediment

Contaminants and concentration ranges that have been identified in on- and off-site soils and in off-site river sediments are tabulated in Appendices B and C. On-site soil contains elevated levels of arsenic, lead, and mercury. (These metals, including cadmium, are also found in dust removed from the chicken coops.) Arsenic has consistently been found in off-site soil and river sediments at elevated levels. Cadmium, lead, and mercury have been found at lower levels, and cadmium and mercury contamination, in general, is localized in the Blackwater Branch sediments.

ViChem personnel and remedial workers may be exposed to contaminants in surface and subsurface soils via ingestion, dermal absorption, and

inhalation of fugitive dusts. Arsenic concentrations in the air were measured during the installation of the Ebasco wells, and arsenic levels were also measured in the air inside Building #9. Concentrations measured during this sampling activity are given in the Draft Plant Site RI and were not at levels that pose adverse health effects. However, future remedial activities could lead to a substantial increase of contaminated soil resuspended in the ambient air. Protective clothing should be worn during remediation activities that may expose workers to contaminants in surface and subsurface soils. The New Jersey Division of Science and Research has monitored dust levels in the areas exposed by the lowering of Union Lake and found these not to be health-threatening (New Jersey Department of Environmental Protection, letter to New Jersey Department of Health, March 31, 1989).

Health effects associated with exposure to arsenic adsorbed to soil and sediment are the same as those summarized above for concentrations in water. Mercury is found predominantly in on-site soils and may pose risks to on-site workers. Exposure to mercury can cause gastrointestinal tract irritations and central nervous system effects; however, appropriate personnel protective equipment should significantly reduce the risks associated with this contaminant.

Conclusions of EPA's Vineland Chemical Company risk assessments and comparison of EPA risk assessments and ATSDR health assessments

The Region II EPA contractor, Ebasco, conducted risk assessments for each of the ViChem RIs. Results of these assessments led to the following conclusions concerning the public health implications associated with the site:

- At the plant site the major risk to workers is from inhalation exposure to contaminants adsorbed onto on-site surface soils. This exposure could result in excess cancer risks.

- Nearby residents downgradient of the plant site using well water would be subjected to increased carcinogenic and noncarcinogenic risks.

- Ingestion of arsenic contamination found in the water, sediment, and biota from the Maurice River above Union Lake also posed excess cancer risks to receptors.

- Dermal contact with the water and inhalation of vapors from the Maurice River were deemed insignificant, and noncarcinogenic risks were generally minor.

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Contamination in the lower Maurice River was determined to pose no increased health risks from exposure to arsenic-contaminated water, sediment, or biota. This was based both on differences in exposure pathways between the upper and lower sections of the river and on the generally lower arsenic concentrations below Union Lake.

The risk assessment conducted on data from Union Lake assumed that all of the arsenic was in the most toxic form (trivalent) of the four arsenic species found in the lake and determined that for a combination of all possible exposure pathways the arsenic contamination in the lake resulted in an excess cancer risk.

Of the risk involved with ingestion of fish from the lake, most resulted from concentrations of PCBs in the fish tissue. The PCB contamination in the lake most likely results from a combination of nonpoint sources and is not attributable to the plant site.

The product of a quantitative risk assessment, such as those included in EPA's Remedial Investigations, is a numerical estimate of the public health consequences of exposure to an agent. EPA Risk Assessments are used in risk management decisions to establish cleanup levels; set permit levels for discharge, storage, or transport of hazardous waste; and determine allowable levels of contamination.

Health assessments conducted by ATSDR also utilize quantitative estimates; however, the conclusions of a health assessment are usually qualitative and focus on medical and public health perspectives associated with exposure to a site. Thus, while the risk assessments conducted by EBASCO in the ViChem RIs might lead to the selection of a particular remediation measure, this HA is to be used by local health professionals and residents to understand the potential health threats posed by the ViChem site.

CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

Based upon the information reviewed, ATSDR has concluded that this site is of potential health concern because of the potential risk to human health resulting from possible exposure to hazardous substances at concentrations that may result in adverse human health effects. As noted in the Human Exposure Pathways Section above, human exposure to arsenic may be occurring and may have occurred in the past via

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ingestion, inhalation, and/or dermal absorption of contaminated groundwater, surface water, surface and subsurface soil, sediment, and aquatic biota.

Although levels of the contaminants of concern in groundwater, surface water, and sediments greatly exceed health-based standards at locations on-site and in Blackwater Branch, no known exposure is occurring at these locations or concentrations.

Without remediation of on-site groundwater, arsenic concentrations in the Blackwater Branch and the Maurice River are likely to remain high, since the on-site groundwater is recharging Blackwater Branch and the wells closest to Blackwater Branch contain very high arsenic concentrations.

B. RECOMMENDATIONS

1. Public access to on-site areas should be prevented. Highly contaminated areas, such as the former outdoor storage area near ER-14, are not contained within the plant fence and are easily accessible from the roads surrounding the area.
2. Public access to Union Lake should continue to be restricted, especially access for the purpose of swimming or fishing, until the repairs to the dam are completed and the lake is restored to its normal water level. Public access to off-site areas with high concentrations of arsenic in sediment (particularly the sediments in Blackwater Branch) should be minimized by posting warning signs.
3. Discharge of non-contact cooling water to an unlined lagoon should cease, since percolation of this water through highly contaminated surface and subsurface soils enhances leachate production and the off-site migration of contamination to the nearby Blackwater Branch.
4. A survey on water well use should be conducted in the residential area to the west of the plant site to assess the use of potentially contaminated groundwater for potable supplies or for other domestic uses.
5. Groundwater monitoring wells should be installed to the west of the plant site, across Mill Road, to determine if the westward off-site migration of groundwater has resulted in contamination in this area. Groundwater monitoring wells should also be installed north of the plant site (specifically north of the lagoon and manufacturing areas) across the Blackwater Branch, to determine if groundwater from these heavily contaminated areas has migrated underneath Blackwater Branch.

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6. The chickens housed in the room in chicken coop #4 (formerly used to store raw chemicals) should be removed since dust samples from this coop indicate metal contamination and since metals may bioaccumulate in chickens and eggs used for consumption.
7. In accordance with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended, the Vineland Chemical Company NPL site has been evaluated for appropriate follow-up with respect to health effects studies. Although human exposure to on-site/off-site contaminants may be currently occurring (and may have occurred in the past), this site is not being considered for follow-up health studies at this time because human exposure to contaminated media at contaminant levels and at exposure frequency and duration necessary to result in adverse health effects are not known to be occurring.

PREPARERS OF THE REPORT

Vicki J. Brumback
Robin K. White, Ph.D.
Office of Risk Analysis
Oak Ridge National Laboratory

REVIEWERS OF THE REPORT

Dennis Jones
Office of Health Assessment
Agency for Toxic Substances and Disease Registry

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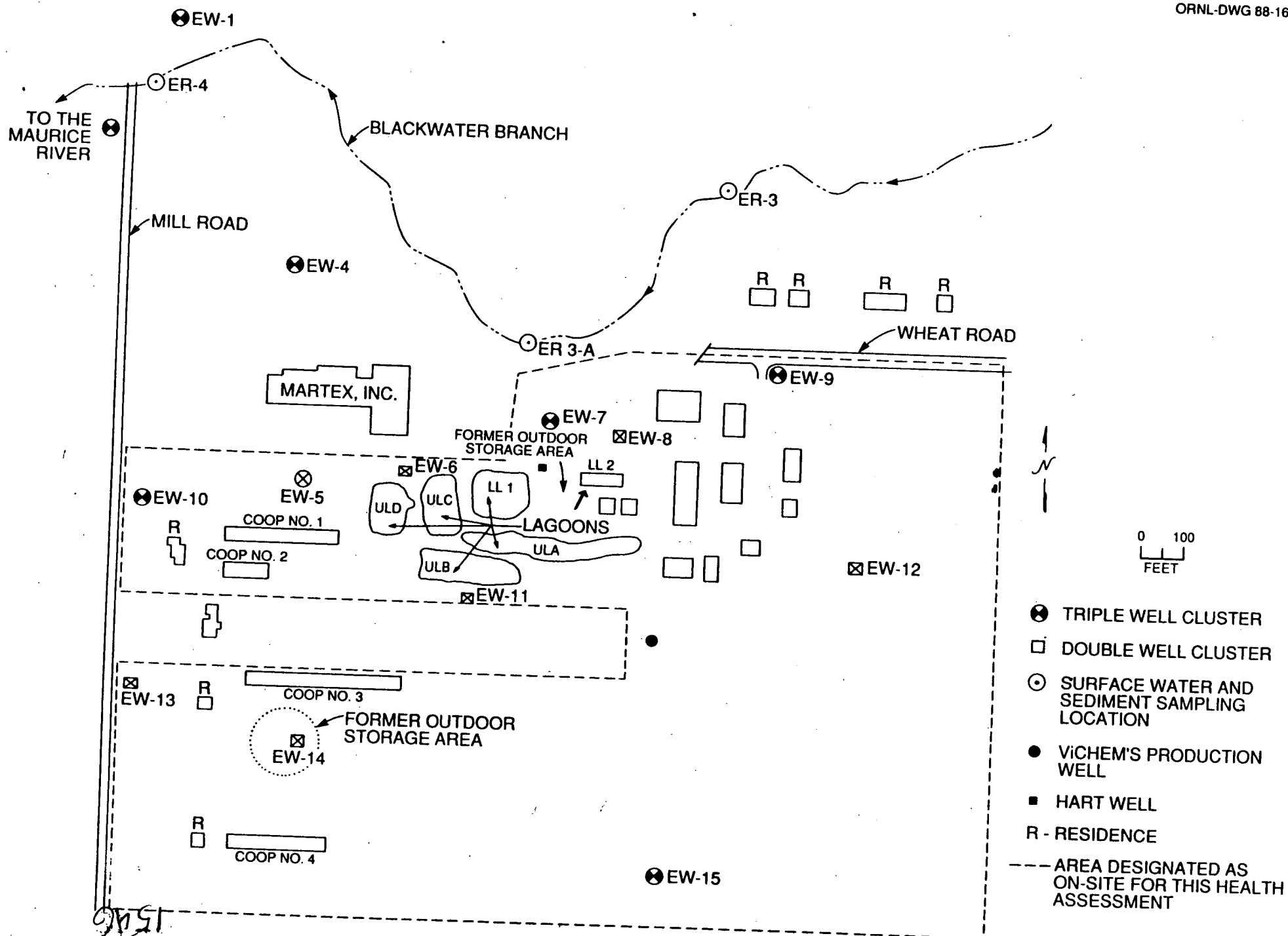
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APPENDICES

Appendix A: Plant site map

Appendix B: On-site contamination at ViChem

Appendix C: Off-site contamination near ViChem



Appendix B: On-site contamination at ViChem

GROUNDWATER (water table aquifer) (Concentration Range in ug/l)

Ebasco Wells (EW)

Parameter	Shallow	Middle	Lower
Antimony	33U - 831	33U - 62	58U - 330
Arsenic	3U - 12,600	33 - 15,800	1.5U - 28
Cadmium	4U - 457	4U - 623	4U - 4.9J
Lead	2.9U - 4.5J	2.9U - 110	2.9U - 99.3J
Mercury	.2U - 1J	.2U - .2U	.2U - .26J
Trichloroethene	5U - 190	1.2J - 260	5U - 5U

Concentration Range (mg/kg)

SURFACE SOIL (from top 0 - 2 feet)

Parameter		SURFACE SOIL (beneath Building #9)	SUBSURFA (beneath)
Antimony	13U - 35U	14U - 15U	14U -
Arsenic	.43 - 650	156 - 1,430	7.5 -
Cadmium	1.2U - 2U	1.9U - 2U	1.9U -
Lead	2.1U - 12	2.6U - 2.7U	2.6U -
Mercury	.1U - 11.3	.1U - .1U	.1U -
Trichloroethene	5U - 25U	5U - 6U	5U -

SUBSURFACE SOIL

Concentration Range (mg/kg)

(Soil borings
from 2' to end of boring)

(Soil retrieved during installati

Parameter		Shallow	Middle
Antimony	13U - 29U	6.8U - 35	7.1U - 29U
Arsenic	18U - 103	1.1U - 59	6.8 - 82.9
Cadmium	1.5U - 2.9U	.4U - 2.3U	.4U - 2.4U
Lead	1U - 2.8	1U - 4.9	1.1U - 22
Mercury	1U - 1U	.1U - .4	.1U - .2
Trichloroethene	5U - 25U	5U - 19U	5U - 6,850U

CHICKEN COOP DUST

LAGOON SEDIMENT

Parameter	Concentration Range (mg/kg)	Concentration Range (mg/kg)	LAG Concen
Antimony	4.3J - 55	NA	
Arsenic	114 - 5,120	25 - 185	
Cadmium	1.2 - 125	NA	
Lead	23 - 289	NA	
Mercury	.73 - 12.2	NA	
Trichloroethene	NA	NA	

Arsenic concentrations in the air were measured during the installation of the Ebasco were also measured inside building #9. The arsenic concentration range during this sa 0.09U - 0.2 ug/m³.

U - parameter was not measured above instrument detection limit (number is the detecti
J - value of parameter was estimated
NA - sample was not analyzed for this parameter

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Appendix C: Off-site contamination near ViCh

GROUNDWATER (water table aquifer)

Concentration Range (ug/l)

Parameter	Shallow	Middle	Lower
Antimony	33U - 58U	33U - 58U	33U - 58U
Arsenic	6U - 657	1.5U - 394,000	1.5U - 30
Cadmium	4U - 20	4U - 9,580	4U - 4.7U
Lead	2.9 - 3.4J	2.9U - .65.2	4.3J - 97
Mercury	.2U - .2U	.2U - .2U	.2U - .2U
Trichloroethene	5U - 5U	5U - 6	5U - 5U

SOIL

Concentration Range (mg/kg)

Subsurface soil
(Soil retrieved during installation of Ebasco Wells)

Sur
(fr

Parameter	Shallow	Middle	Lower
Antimony	1.1U ¹ - 7.3U	7.27U - 14U	11U - 39
Arsenic	1.1U ¹ - 1.1U	5.3U - 61.4	2.4U - 2.9J
Cadmium	.89U - 1.1U	1.06J - 2U	.6J - 1.6U
Lead	3.25 - .1U	2.7U - 23	1.4J - 3.1
Mercury	.1U - .11U	.1U - .1U	.1U - .1U
Trichloroethene	5U - 6U	5U - 9U	6U - 685U

SURFACE WATER

Concentration Range (ug/l)

Parameter	Blackwater Branch (upstream ²)	Blackwater Branch (downstream ³)	Maurice River (above Union Lake)	Union Lake
Antimony	20U - 33U	20U - 33U	20U - 33U	ND - 40
Arsenic	2.2J - 6U	4.8J - 6,200	123 - 570	10 - 187
Cadmium	3.6U - 4.6J	3.6U - 4U	3.6U - 5U	ND - 5.8
Lead	29.4 - .2U	7.5 - .2U	2.3J - 50U	ND - 24
Mercury	.2U - .6	.2U - .8	.2U - .5	ND - 12
Trichloroethene	5U	5U	2J - 11	NA

SEDIMENT

Concentration Range (mg/kg)

Parameter	Blackwater Branch (upstream ²)	Blackwater Branch (downstream ³)	Maurice River (above Union Lake)	Uni
Antimony	8.3U - 12.2U	10.7U ¹	4.6U - 9.7U	
Arsenic	.9UJ - 14UJ	7.7J - 12,800	.9UJ - 922	ND
Cadmium	1.21J - 3.9	8.3	.83U - 1.8U	
Lead	6.1 - 337	5.5 - 23.3	1.95 - 33	50
Mercury	.12U - 10	.16 - .6J	.11U - 1.1	
Trichloroethene	5U - 10U	5U	5U - 10U	

BIOTA (Biota samples were not analyzed for other inorganic compounds or trichloroethe

Concentration Range (mg/kg)

Parameter	Maurice River (above Union Lake)	Union Lake	Maurice Lake (below Union Lake)
Arsenic	.91 - 2U	<20 - 240	1U - 1.6

- U - parameter was not measured above instrument detection limit (number is the detection limit)
 J - value of parameter was estimated
 R - all values were rejected for this parameter
 NA - sample was not analyzed for this parameter
 ND - parameter was not measured above instrument detection limit (detection limit)
 1 - one value represents only one sample
 2 - sampling locations were upstream of the plant site
 3 - sampling locations were downstream of the plant site

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